04 Research Activities

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NanoBiotech Laboratory

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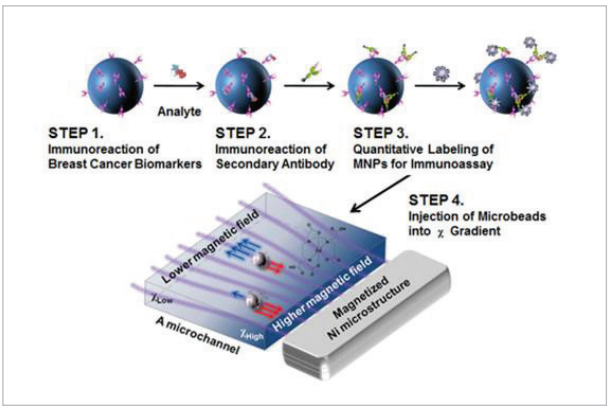
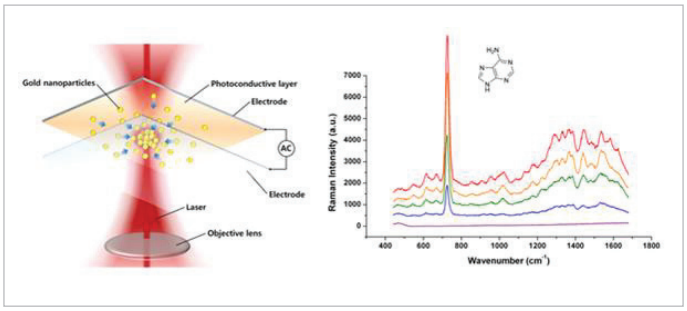
Recent progress of lab-on-a-chip technology is challenging for the development of nanobiotechnology and integrative bioengineering. Particularly, micro/nano fluidics has been a key technology for the realization of micro total analysis systems (μTAS) or lab-on-a-chip as well as the next generation bio-tools for drug discovery, diagnostics, and tissue engineering. This research area covers the design and development of miniaturized devices that manipulate liquid samples at nanoliter volumes, allowing biological assays to be integrated and accomplished on a small scale with minimum time and cost. Prof. Park's research focuses on the development of a nanobiosensor, microfluidic device and lab-on-a-chip as a new platform for biological sample processing, separation, and detection, including optoelectrofluidics, hydrophoretic separation, magnetophoretic assay, and cell-based assay. From June 2008, his laboratory has been selected to receive a National Research Laboratory (NRL) Program grant through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (MEST).

Isomagnetophoretic Immunoassay: Isomagnetophoresis can be used to discriminate subtle differences in magnetic susceptibility by using a magnetic susceptibility gradient in a microfluidic channel. In isomagnetophoretic immunoassays, the magnetic nanoparticles are used as labels on microbeads in sandwich-type immunoassay, detecting the amount of bound analytes by isomagnetophoretic focusing the solid-support microbeads under the magnetic susceptibility gradient and magnetic field in a microchannel. One advantage of the method is that the dynamic range of the isomagnetophoretic immunoassay system can be adjusted by altering the magnetic susceptibility gradient. In addition, this isomagnetophoretic immunoassay system can be used to analyze the selected concentration of target analytes in detail by tuning the dynamic ranges. As isomagnetophoresis can reduce signal deviation and discriminate subtle magnetic susceptibility differences, this immunoassay scheme shows an attomolar level of detection limit and a very low coefficient of variance of 1.29% [1]. The proposed immunoassay can be useful to accurately quantify the concentrations of biomarkers over the whole range of analyte concentrations, based on the current status and needs of the patient.

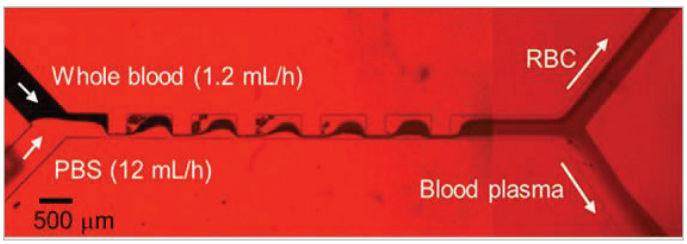


Optoelectrofluidic SERS spectroscopy: Optoelectrofluidic technology allows programmable manipulation of particles or fluids in microenvironments based on optically induced electrokinetics resulted from photochemical,

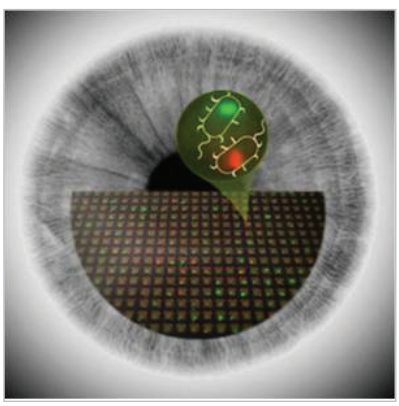


photoconductive, and photothermal effects. This new platform could be applied to develop an integrated system for optoelectrofluidic manipulation of micro- and nanoparticles including living cells and biomolecules [2a]. We recently reported a novel active surface-enhanced Raman scattering (SERS) platform for dynamic on-demand generation of SERS active sites based on optoelectrofluidics [2b]. When a laser source is projected into a sample solution containing metal nanoparticles in an optoelectrofluidic device and an AC electric field is applied, the metal nanoparticles are spontaneously concentrated and assembled within the laser spot, form SERS-active sites, and enhance the Raman signal significantly, allowing dynamic and more sensitive SERS detection. In this simple platform, both dynamic concentration of metal nanoparticles and in situ detection of SERS signal are simultaneously possible with only a single laser source. This approach allows on-demand generation of 'hot spots' at specific regions of interest, and highly sensitive, reliable, and stable SERS measurements of the target molecules in a tiny volume of liquid sample without any fluidic components and complicated systems.

Inertial Microfluidic Separation: Recently, inertial microfluidic separation is of great interest due to its continuous and high throughput separation of cells. To take advantages of high throughput, simple fabrication and high separation resolution, we have developed a new strategy for microfluidic separation using the force balance between inertial lift and Dean drag forces in a contraction-expansion array (CEA) microchannel [3a]. From this modulation of force balance, the particle cutoff size value can be tuned into proper value according to target cell size. In the CEA microchannel, an abrupt change of the cross-sectional area of the expansion regions curves fluid streams and produces a similar effect compared to Dean flows in a curved microchannel of constant cross-section, thereby inducing Dean drag forces acting on particles or cells. In addition, the particles or cells are influenced by inertial lift forces throughout the contraction regions. Accordingly, the force balancing determines whether the particles or cells cross the channel. Continuous inertial blood plasma separation is also demonstrated in a CEA microchannel with a low aspect ratio, which causes the change in magnitudes of the inertial lift forces on the particles [3b].



Microdroplet array for single-cell-based assay: A single-cell-based assay has been demonstrated using a mesh-integrated micro well array which enables easy trapping and consistent addition of droplets in a high-throughput manner [4]. The mesh-integrated droplet array provides a microfluidic platform for simple storage and on-demand merging of droplets. The openness of the system allows easy access to individual droplets and variable integration with other functional modules. By integrating the single-cell droplet-generating channel, the mesh-integrated microarray allows immediate confinement of single cells and total isolation of each chamber throughout the entire droplet manipulation process. With further development of cell-friendlier conditions and automation for parallel handling of droplets, this device may provide a novel screening platform, especially for various microbes directly harvested from a natural environment.



References

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2. **a)** Hyundoo Hwang, Je-Kyun Park*, "Optoelectrofluidic manipulation of nanoparticles and biomolecules, Adv. OptoElectronics, **2011**, 2011, Article ID 482483; **b)** Hyundoo Hwang, Dongsik Han, Young-Jae Oh, Yoon-Kyoung Cho, Ki-Hun Jeong, Je-Kyun Park*, "In situ dynamic measurements of the enhanced SERS signal using an optoelectrofluidic SERS platform," Lab Chip, **2011**, 11 (15): 2518-2555.
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